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The Optimal Matching Algorithm for Multi-Scale Iris Recognition

XiaoZhou Chen, ChangYin Wu, LiangLin Xiong, Fan Yang*

School of Mathematics and Computer Science, Yunnan University of Nationalities, Kunming 650031,China

Abstract

As one of the most effective ways in biometrics, Iris Identification has drawn more and more attention in recognition technology. Fruitful achievement， both theoretically and practically, have been made and widely applied to various fields and industries. However, iris identification is easily affected by noises such as eyelashes, eyelids, sampling flares, and its quality and speed in actual practice is not so effective. We analyses the general approach based on the extraction and matching of feature code, and then design an new iris identification algorithm based on multi-scale gray matching. It proposes a standardized solution for the noise integration of using in login and sample iris images, and uses directly surface match way to judge recognition.With the method, we can extract more junior primitive iris data, analyses and process them, and increase area used to iris identification, reduce residual caused by the no unified available area. The results show that the algorithm has virtues of both accuracy and speed, and has some applicated fields..

Keywords: Iris identification; Gray surface matching; Feature extraction

1. Introduction

Currently, the iris identification is widely applied, but it is only designed for the community with small scale. As for the billions of large-scale searches, it will take a lot of time to get the results, which will be invalid in the real-time processing. The errors in the process of capturing images have brought the appropriate difficulties to the post-processing. In the process of dealing with the images, the iris images haven't been properly divided. The effective iris has been abandoned and the feature extraction hasn't

*Ccorresponding author. Tel.: +86 871 5913120
E-mail address: kmyf@tom.com; ch_xiaozhou@yahoo.com.cn

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been involved. Sometimes, the phenomenon that some noise is added as the iris to extract the features is often available. In order to really improve the advantages of this biometric feature identification[1], the further study is needed. Firstly, it is required to standardize the image acquisition, improve or seek the new algorithm to maximize the speed of operation. If it can be completed in one or two seconds under the condition of billions of searches, it will be widely applied in various fields. Only the time is shortened as much as possible, the matching identification will be conducted as easily as the identity card. The study and the development of iris identification technology are related to various fields such as the computer vision, the digital image processing, the wavelet transform theory and the pattern identification, etc[2]. The multi-resolution has been employed to analyze the relationship between the sampling density and the identification effect. However, it is not conducted in the complete and uniform regions in most cases, which will increase the false reject rate(FRR) or the false accept rate(FAR)[3]. In the unification regions, the basis as well as the noise is the same. The threshold can be set and the noisy regions can be completely eliminated. Even if there is the error, it is just the smooth error in the color saturation. It can be also considered that the iris has the same feature domain. It is required to use the image processing method to directly calculate the distance of the corresponding pixel. And the threshold should be set so as to obtain the matching results.

2. The iris identification

The original iris images have collected an eye image. The iris should be split from the images and the other non-iris regions are known as the noise, then the complete iris identification system will be established. Firstly, it is required to position the iris regions and the accuracy of positioning will directly affect the iris identification. The iris normalization should be conducted in the uniform iris regions. The light environmental differences as well as the man-made non-positive offset in the capturing process of iris images will greatly affect the iris extraction. The feature extraction of iris is conducted in the normalized iris images. It is required to use the processing method of digital images to judge the points, the lines, the surfaces and some others on the iris textures. The typical iris features include the spatial domain features, the frequency features and the combination features of them. Each iris image can contain more than two hundred kinds of features, but they are not the same. These features should be extracted and stored in the iris feature libraries. As for the login iris, it is necessary to employ the same techniques to extract the corresponding features. In general applications, the iris information is extracted from the iris after being sampled, positioned, normalized and encoded. Then we will get a series of feature codes rather than the iris images. These feature codes should be stored in database, which can be called the registered iris feature codes. When the login iris image requires the identity authentication, it is also necessary to extract the feature codes and the matching of feature codes in the registered iris database through the real-time operations.

3. The analysis of the advantages and the disadvantages of the existing iris identification technologies

The iris positioning segmentation and the iris normalization are the key to the successful identification. The core of the iris identification is to extract the feature information of iris and then match them with other iris features. In the extraction of iris information, the Gabor filters[4] have the adjustable directions, the bandwidth, the adjustable CF and the joint optimal resolution which can simultaneously reach the spatial domain and the frequency domain. 2-D Gabor[5]

$$\begin{cases} G(x,y) = A_1 * A_2 \\ A_1 = \exp\left\{-\left[(x-x_0)^2\alpha^2 + (y-y_0)^2\beta^2\right]\right\} \\ A_2 = \exp\left\{-2\pi i\left[u_0(x-x_0) + v_0(y-y_0)\right]\right\} \end{cases} \tag{1}$$

The transformation is suitable for containing some specific features and the multi-direction textures. The Daugman phase encoding[6] is the most mature and the most suitable algorithm in the practical application ate present. However, is has a higher requirement for the iris raw data. Therefore, the images with higher resolution are demanded in the process of collecting the iris, but the speed will be obviously affected. The Pyramid law[7] can be shown as follows:

$$G(\rho,\sigma) = -\frac{1}{\pi\sigma^4}\left(1-\frac{\rho^2}{2\sigma^4}\right)\exp\left(-\frac{\rho^2}{2\sigma^4}\right) \tag{2}$$

It has adopted the multi-resolution spectrum analysis, which has a higher requirement for the amount of iris data sampling. The results of the matching based on the sub-block features[8] are good, but the multidirectional searches have caused the increase of matching time. Currently, as for the widely-used systems, the feature information is extracted based on the wavelet transformation. The features should be extracted firstly and then they are required to be matched. As the features of iris image have been converted to the numeric codes, so the matching speed of the iris features will be fast under the condition of excellent database. However, in the process of feature extraction, the speed is slower. And in some cases, the various mathematical tools are just encoded according to their own methods, which is inconvenient for the sharing among the enterprises. At the same time, the accuracy and the identification time is also inconsistent, which will bring some difficulties to the practical application.

4. The direct gray-scale surface matching technique

As for the direct gray-scale matching method, the feature extraction has been omitted. Then the encoding matching does not exist. It just contrasts and calculates the normalized iris images according to the gray values. The fundamental part lies in the calculation based on the iris image textures. As for the gray-scale image $\mathrm{f}(x,y)$, x represents the pixel width and y refers to the pixel height. In order to facilitate the numerical processing, the values of x and y should be limited in the first quadrant of Cartesian coordinate system. As for the two images $\mathrm{f}_1(x,y)$ and $\mathrm{f}_2(x,y)$, it is required to judge whether the two images are the same under the condition of same pixel value. At the same time, it is also necessary to use the computer to calculate the difference of gray-scale value of the corresponding pixel: $\Delta F(x,y) = \left|\mathrm{f}_1(x,y) - \mathrm{f}_2(x,y)\right|$. If $\Delta F(x_0,y_0) = 0$, then we can find that the two images at (x_0,y_0) are the same.

$$f_z(a,b) = ABS(f_X(a,b) - f_Y(a,b)) \tag{3}$$

$$\begin{cases} \mu = \dfrac{1}{mn}\displaystyle\sum_{y=0}^{n-1}\sum_{x=0}^{m-1} f_z(a,b) \\ \sigma^2 = \displaystyle\sum_{y=0}^{n-1}\sum_{x=0}^{m-1}(f_z(a,b) - \mu)^2 \end{cases} \tag{4}$$

It is required to find the difference of the whole pixels and obtain the variance. The variance threshold should be set in a range so as to determine whether the two images are the same. Based on this idea, as for the normalized iris images, we can also adopt the comparison method among the pixels. The speed of CPU processing is quite fast to contrast the two images with 320×280 pixel. The focus of the general algorithm falls on the feature points such as the points, the lines and the surface of iris texture structure. Therefore, it is required to employ the complex math means and the complex formulas. But the speed of experiment is not satisfactory, which always takes more time. At the same time, the quality of identification is easily affected by the selected filter and the parameters. Some key points may be overlooked to cause the wrong results of identification.

5. The analysis of the scale iris identification

5.1 Unified-Noise Model

The iris images after the noise unification has undoubtedly ensured the sufficient effective iris regions to conduct the identification. However, the computation is still large. It is required to adopt a certain ways to filter out some pixels without affecting the identification results.

5.2 the iris image after noise unified

The optimization ideas under the condition of multi-resolution have been proposed in this paper. The iris images used in this paper are from the CASIA Iris Image Database 1.0. The image is the gray-scale bmp format image with a resolution of 320×240. The resolution of extracted iris regions is 32×240. The line by line scanning and the point by point scanning will take a lot of time. If the size of the normalized iris regions is $M \times N$, the pixels will be contrasted point by point and the M*N operations will be appeared. If M is conducted the line jump matching calculations, the speed will be twice as fast. If the lines and the lists are all employed the line jump matching calculations, the number of operations will be reduced to a quarter of the original number. The experiment has proved the existence of optimum stratification, namely the number of stratifications should ensure the quality of identification and the speed should be within an acceptable range. When the iris images are normalized, we can get the 32×240 image, which also contains the noisy regions. If they all adopt the calculation matching, 70000 points will be exceeded. Currently, although the hard configuration is higher and higher, a large amount of searches and matching will inevitably increase the consumption of resources.

The matching and the identification results of the images collected by the same eye at different times can be shown in Table 1. The greater the δ is, the higher the probability that the two iris images refers to the same eye will be. The results of the different eyes can be shown in Table 2. Table 3-4 are deduced by analogy.

Tab 1 The same eye（full）

δ	P2	P3	P4	P5	P6	P7
P1	0.0838	0.0552	0.0657	0.0692	0.0691	0.0605
P2	0	0.0821	0.0904	0.0926	0.0955	0.0919
P3	0	0	0.0608	0.0627	0.0712	0.0534
P4	0	0	0	0.0752	0.0741	0.0566
P5	0	0	0	0	0.0875	0.0723
P6	0	0	0	0	0	0.077

Tab 2 The different eye（full）

δ	P2	P3	P4	P5	P6	P7
P1	0.1321	0.1864	0.1505	0.1492	0.1372	0.1475
P2	0	0.2068	0.1347	0.1511	0.1304	0.1357
P3	0	0	0.1905	0.1854	0.1835	0.1989
P4	0	0	0	0.1392	0.1629	0.1616
P5	0	0	0	0	0.1343	0.1770
P6	0	0	0	0	0	0.1876

From Table 1 and Table 2, we can find that the values of variance have been reduced to some extent. It is relative to the phenomenon that the concentration ratio of identification has been increased without improvement. The distance of the difference of variance which is used to determine whether they belong to the same eye has been increased, which can be considered as the effective improvement for the iris identification. From Figure1 to Figure 4 we can find that the concentration ratio of the scatter diagrams from the same iris is significantly different from the one of the scatter diagrams form the different iris. There is no cross situation in the two groups.

Tab 3 The same eye（one line jump）

δ	P2	P3	P4	P5	P6	P7
P1	0.0581	0.0355	0.0481	0.0462	0.0459	0.044
P2	0	0.059	0.0545	0.0591	0.0455	0.0569
P3	0	0	0.0421	0.0411	0.0504	0.0355
P4	0	0	0	0.0553	0.0526	0.0413
P5	0	0	0	0	0.0637	0.0517
P6	0	0	0	0	0	0.0569

Tab 4 The different eye（one line jump）

δ	P2	P3	P4	P5	P6	P7
P1	0.0998	0.1456	0.0781	0.0876	0.0686	0.0818
P2	0	0.1698	0.0714	0.1163	0.0808	0.0913
P3	0	0	0.1495	0.1392	0.1393	0.1491
P4	0	0	0	0.1067	0.0816	0.0869
P5	0	0	0	0	0.0989	0.1087
P6	0	0	0	0	0	0.0837

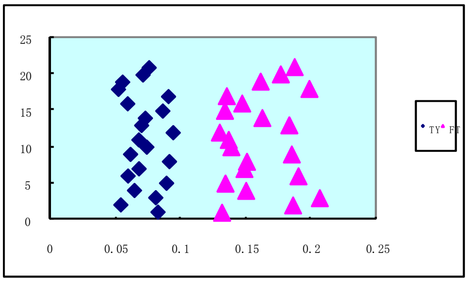

Fig 1 Full scatter display

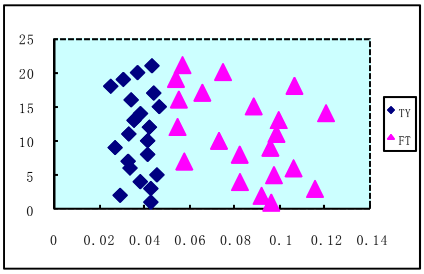

Fig 2 one line jump scatter display

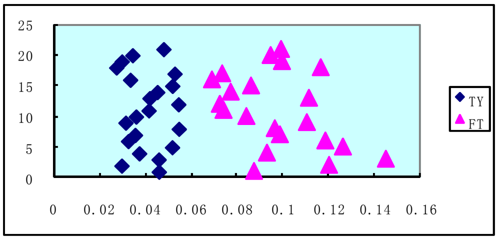

Fig 3 two line jump scatter display

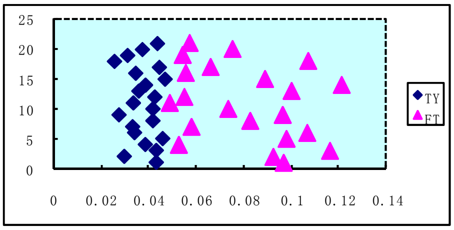

Fig 4 three line jump scatter display

It has been difficult when it is conducted in two line jump before the improvement. When it is conducted in three line jump, the false accept rate will be increased. There are three pairs of false identification in the 21 pairs of matching. As for the improved multi-scale matching algorithm, it has maintained a satisfactory speed. At the same time, the good identification results have been also maintained even the matching is conducted in three line jump. There is no false identification and the false rejection in the 21 pairs of iris matching. According to the scatter diagrams, we can also find that the iris whether they belong to the same eye under various resolutions have maintained a high group independence, which also verifies that the effect of algorithm is very obvious.

6. Conclusion

According to the characteristics of the iris images extracted by the existing iris identification system in the non-invasive mode, the influence of the size of iris on the results of iris identification has been discussed in this paper. The idea of noise unification has been introduced to the process of iris identification and matching, which has increased the effective regions of iris and improved the accuracy of iris identification. Considering that the extraction speed of feature points is slower, it is required to employ the direct gray-scale surface matching method which is based on the multi-resolution and used for optimizing the iris matching and identification so as to improve the speed of identification. After the study on the three scales, a certain identification effect and the faster identification speed have been obtained. At the same time, the existing direct gray-scale matching algorithm of iris has been improved and optimized. However, the single identification is difficult to ensure the accuracy and the security of identification. The multi-model identity recognition has combined with a variety of identification techniques. It is based on a biometric identification and supplemented by other identification technologies, which is the general trend of the future.

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